

Claims

1. A method of extending time before water in an accumulator freezes within a fuel cell power plant in an ambient below freezing temperature, comprising:
completely insulating said accumulator with vacuum
5 insulation panels;
providing a keep-warm heater between said accumulator and said vacuum insulation panels; and
providing power to said keep-warm heater whenever the temperature of said accumulator approaches freezing temperature.

2. Apparatus for extending time before water in an accumulator freezes within a fuel cell power plant in an ambient below freezing temperature, comprising:
vacuum insulation panels completely insulating said
5 accumulator;
a keep-warm heater between said accumulator and said vacuum insulation panels; and
means for providing power to said keep-warm heater whenever the temperature of said accumulator approaches freezing
10 temperature.

3. A method of retaining capacity of an auxiliary DC power source selected from (a) a battery and (b) a supercapacitor for a fuel cell power plant in an ambient below freezing temperature, comprising:
5 completely insulating said source with vacuum insulation panels;

providing a keep-warm heater between said source and said vacuum insulation panels; and

10 providing power to said keep-warm heater to maintain said source at or above a temperature at which said source has about half of its power capacity.

4. Apparatus for retaining capacity of an auxiliary DC power source selected from (a) a battery and (b) a supercapacitor for a fuel cell power plant in an ambient below freezing temperature, comprising:

5 vacuum insulation panels completely insulating said source;;
a keep-warm heater between said source and said vacuum insulation panels; and

means providing power to said keep-warm heater to maintain said source at or above a temperature at which said source has about
10 half of its power capacity.

5. A method of extending time before water in an accumulator freezes within a fuel cell power plant in an ambient below freezing temperature, comprising:

5 completely insulating said accumulator with first vacuum insulation panels;

providing a first keep-warm heater between said accumulator and said first vacuum insulation panels;

providing an auxiliary dc power source selected from (a) a battery and (b) a supercapacitor, completely insulated with second vacuum insulation panels and having a second keep-warm heater
10 between said source and said second vacuum insulation panels; and

providing power from said source to said second keep-warm heater to maintain said source at or above a temperature at which said source has about half of its power capacity; and

15 providing power from said source to said first keep-warm heater whenever the temperature of said accumulator approaches freezing temperature.

6. A fuel cell power plant, comprising:

a stack of fuel cells, each cell having water flow channels;

a water pump;

5 a water accumulator having a water suction outlet connected to said pump, said water accumulator having double walls with at least one first vacuum insulated panel (VIP) encapsulated therebetween;

an auxiliary DC power source selected from (a) a battery and (b) a supercapacitor;

10 a container for said source, said container having double walls with at least one second VIP encapsulated therebetween;

a first keep-warm heater disposed between a first inner wall of said water accumulator and said at least one first VIP;

15 a second keep-warm heater disposed between an inner wall of said container and said at least one second VIP;

a controller;

a temperature sensor within said accumulator providing to said controller a first signal indicative of temperature in said accumulator;

20 a temperature sensor within said container providing to said controller a second signal indicative of temperature in said container;

25 said controller causing power from said source (c) to be applied to said second keep-warm heater to retain said source at a sufficient temperature so as to retain on the order of one-half of the capacity of said source, and (d) to be applied to said first keep-warm heater to retain temperature of said accumulator at or above freezing temperature.

5 7. A fuel cell power plant, comprising:
a stack of fuel cells, each having water flow channels;
a water pump;
a water accumulator having a water suction outlet connected
to said pump;
a controller;
a temperature sensor within said accumulator providing to said controller a signal indicative of temperature in said accumulator;
a microwave heater disposed in proximity of water in said
10 accumulator; and
said controller, in response to said temperature signal indicating that water in said accumulator is frozen, causing, upon startup of said fuel cell power plant, power generated by said stack of fuel cells to be applied to said microwave heater, thereby to melt
15 the ice in said accumulator.

5 8. A fuel cell power plant, comprising:
a stack of fuel cells, each cell having water flow channels;
a water pump;
a water accumulator having a water suction outlet connected
to said pump, said water accumulator having double walls with at

least one first vacuum insulated panel (VIP) encapsulated therebetween;

an auxiliary DC power source selected from (a) a battery and (b) a supercapacitor;

10 a container for said source, said container having double walls with at least one second VIP encapsulated therebetween;

a first keep-warm heater disposed between a first inner wall of said water accumulator and said at least one first VIP;

15 a second keep-warm heater disposed between an inner wall of said container and said at least one second VIP;

a controller;

a temperature sensor within said accumulator providing to said controller a first signal indicative of temperature in said accumulator;

20 a temperature sensor within said container providing to said controller a second signal indicative of temperature in said container;

said controller causing power from said source to be applied (c) to said second keep-warm heater to retain temperature of said source at a sufficient temperature so as to retain on the order of one-half of the capacity of said source, and (d) to said first keep-warm heater to retain temperature of said accumulator at or above freezing temperature;

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a microwave heater disposed in proximity of water in said accumulator;

30 said controller, in response to said first temperature signal indicating that water in said accumulator is frozen, causing, upon startup of said fuel cell power plant, power generated by said stack of fuel cells to be applied to said microwave heater, thereby to melt ice in said accumulator.

9. A method of retaining capacity of a DC power source selected from (a) a battery and (b) a supercapacitor in an ambient below freezing temperature, comprising:

5 completely insulating said source with vacuum insulation panels;

providing a keep-warm heater between said source and said vacuum insulation panels; and

10 providing power to said keep-warm heater to maintain said source at or above a temperature at which said source has about half of its power capacity.

10. Apparatus for retaining capacity of a DC power source selected from (a) a battery and (b) a supercapacitor in an ambient below freezing temperature, comprising:

5 vacuum insulation panels completely insulating said source;;
a keep-warm heater between said source and said vacuum insulation panels; and

means providing power to said keep-warm heater to maintain said source at or above a temperature at which said source has about half of its power capacity.

11. Apparatus according to claim 10 wherein said means is said DC source.

12. Apparatus according to claim 10 wherein said DC source is a battery in a hydrocarbon-fueled vehicle.